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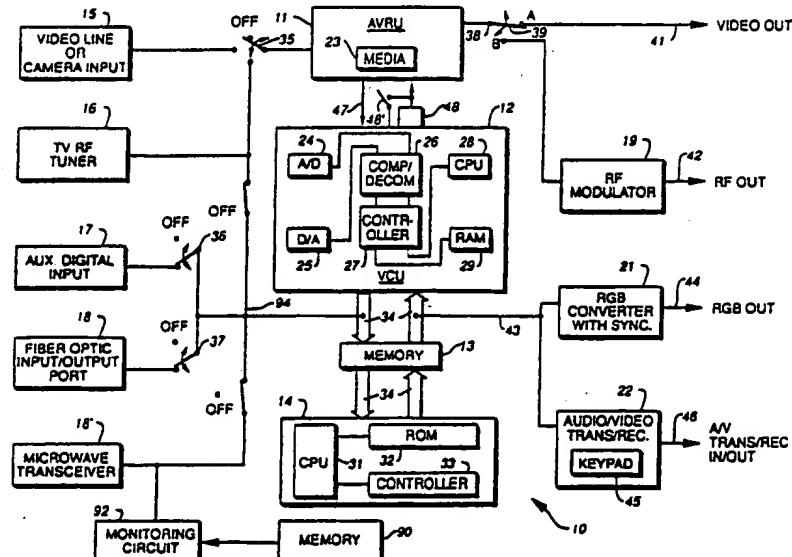
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(54) Title: AUDIO/VIDEO RECORDER/TRANSCEIVER



(57) Abstract

An improved video recorder/transceiver (10) with expanded functionality ("VCR-ET") including a capability for storing video and/or audio programs in digital format, editing such programs, transferring such programs onto a hard copy magnetic media in (23) either compressed or uncompressed form and transmitting such programs in compressed form to a remote location using a second VCR-ET (10). The increased functionality is realised through the use of analog to digital conversion, signal compression and intermediate storage in an integrated circuit, random access memory (29). The recorder/transmitter (10) has capabilities to transmit and receive program information in either a compressed or decompressed format over fiber optic lines (18), conventional phone lines or microwaves or electromagnetic waves in radio or TV band.

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## AUDIO/VIDEO RECORDER/TRANSCEIVER

### BACKGROUND OF THE INVENTION

The video cassette recorder (VCR) has added significantly to the usefulness of the home television set. Important or exceptionally good programs may be recorded to be viewed again. Programs appearing at times that are inconvenient for viewing may be recorded for playback at a later time. Recorded movies or other materials, educational or entertaining, may be rented or borrowed for viewing at home. (As used in the remainder of this specification, the term "program" encompasses movies and other types of video and/or audio materials, whether broadcast from a TV station or another source.)

The typical VCR has its own tuner-receiver and a video-recorder. It can receive and record a program from one channel while the television set is being employed to view a program on another channel. Programs are recorded on magnetic tape. The tape is then played back and viewed on the television set. Features commonly included in the VCR are capabilities for advancing the tape forward or backward at a high speed, stopping motion at any frame to hold the image, or simply playing back the recording at normal speed.

Desirable features that are not normally available in a VCR are capabilities for copying recorded programs from one tape or alternative storage medium to a similar or dissimilar storage medium, editing recorded programs and high speed recording. Another desirable, but currently unavailable, feature is the capability for high speed, high quality transmission and reception by optical fiber, microwave or other communications means using the VCR.

SUMMARY OF THE INVENTION

A video recording device constructed in accordance with my invention is adapted to receive a video program at an accelerated rate and store that video program in a 5 first memory for subsequent viewing. In one embodiment, the video program is received via a fiber optic port, a microwave transceiver, an RF receiver, or other input means. The video signal is typically a digital compressed video signal which may be provided by another video 10 recording device in accordance with the invention or a centrally located video library.

(In another embodiment, instead of receiving a video signal, the recording device receives an audio signal at an accelerated rate. The audio signal may be stored so it 15 can be edited or listened to thereafter.)

The video recording device typically includes an editor for editing the digital compressed video signal stored in memory.

The video recording device also includes compression/ 20 decompression circuitry for decompressing a compressed digital video signal and converting the decompressed digital video signal to an analog video signal for subsequent viewing. In one embodiment, the video recording device also includes a second memory (which can 25 be, for example, a magnetic tape cassette, optical disc, or other recording media) for receiving the decompressed analog video signal for subsequent viewing.

In one embodiment, the video recording device includes input means for receiving a video signal at 30 conventional speeds, such as an RF tuner used to receive conventional analog video signals, a camera input line for receiving an input signal from a TV camera, or other type of input means. The signal received by this input means can be stored in the second memory, and/or digitized,

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compressed and stored in the first memory, and/or viewed on a television monitor.

In another embodiment, the video recording device can receive digital video signals at conventional speeds as 5 well.

These and other advantages of my invention are better understood with reference to the drawings and detailed description below.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Fig. 1 is a perspective view of the housing of the audio/video recorder editor/transceiver ("VCR-ET") disclosed and embodying the invention.

Fig. 1A is an enlarged view of the circled area of Fig. 1.

15 Fig. 2 is a functional block diagram of the VCR-ET of Fig. 1.

Fig. 2A is a functional block diagram of the VCR-ET of Fig. 1 including circuitry for demodulating a video signal encoded using the Vokac technique.

20 Fig. 3 is a functional block diagram of a VCR-ET in accordance with another embodiment of the invention.

Fig. 4 is a functional block diagram of an audio recorder/transceiver constructed in accordance with the invention.

25 Fig. 5 illustrates a plurality of VCR-ET's adapted to receive video signals from a remotely located video library via a common communication channel.

Fig. 6 illustrates a carrier signal modulated using the Vokac modulation technique, described in greater 30 detail below.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing by reference characters, Figs. 1 and 2 illustrate an improved audio/video recorder

editor/transceiver 10 (VCR-ET) comprising an audio/video recording unit (AVRU) 11, a video control unit (VCU) 12, memory 13, digital control unit (DCU) 14, video line or camera input line 15, TV RF tuner 16, auxiliary digital 5 input port 17, fiber optic input/output port 18, RF modulator 19, RGB converter with synchronizer 21, and an audio/video transmitter/receiver 22 with keypad 45, all in a common housing.

The audio/video recording unit AVRU 11 may be a video 10 cassette recorder similar to a conventional VCR in which the storage media 23 is a magnetic tape. Alternatively AVRU 11 may operate with other types of storage media including, but not limited to, optical discs, CD-ROMs or other magnetic tape formats. AVRU 11 has all the 15 functions of the typical VCR including record, play, rewind, slow motion, fast-forward and single frame hold.

An alternate form of storage media for use in AVRU 11 is the CD-ROM, which is a disk using a derivative of glass or plastic in conjunction with an aluminum or other 20 metallic coating. Audio and video signals are stored in the form of irregularities in the aluminum coated surface and are read using a low power laser. In this case, the user would not be able to store or write on the CD-ROM, but would be able to play discs that have been recorded 25 and distributed commercially. The storage of video and audio signals on the CD-ROM is in digital form which is readily accommodated by the video recorder of this invention.

Instead of using a CD-ROM, VCR-ET 10 can use optical 30 discs as media 23. Such optical discs are similar to a CD-ROM and use a variable power laser to read from or write on the disc.

A first type of optical disc is a WORM (Write Once Read Many) optical disc. This device has the unique 35 capability of writing on the disc permanently. A laser is

used to change the magnetic or optical properties of the media. A lower-powered laser is then used to read the data from the disc. Data, in this case, is permanently recorded; it may neither be erased nor written over. A 5 further description of this technology can be found in the November 1988 issue of The Electronic System Design magazine (ESD) pages 55-56, incorporated herein by reference.

10 A second and preferred type of optical disc to be used in AVRU 11 is an erasable optical disc. This disc has full read/write/erase capabilities. With this disc, AVRU 11 has the same record/playback capabilities as a conventional VCR. As an example, erasable optical discs are used in Steven Jobs' "Next" machine as described in 15 Infoworld, Volume 10, issue 42, pages 51 and 93, October 17, 1988, incorporated herein by reference. In addition, the random access capabilities of the erasable disc (and of the CD-ROM and WORM) provide additional benefits as will be discussed in a later part of this 20 specification.

A key element of VCR-ET 10, which is partly 25 responsible for its improved functionality, is the video control unit or VCU 12. The VCU comprises an analog to digital converter (ADC) 24, a digital to analog converter (DAC) 25, a compressor/decompressor 26, a controller 27, a central processing unit (CPU) 28 and a random access memory (RAM) 29. VCU 12, using these elements, accomplishes the digitization and compression of analog signals as well as the reverse process in which the 30 compressed digital signals are decompressed and converted back to analog signals.

As a first step in the processing of the composite video signals within VCU 12, the sync signals are decoded to isolate signals for each picture frame for processing.

35 The video signals defining each frame may then be

converted to a red analog signal, a green analog signal, and a blue analog signal in a conventional manner. The red, green and blue analog signals are then converted to digital form by the analog to digital converter (ADC)

5 24. The frame is divided into a set of closely positioned rows and columns of picture elements or "pixels." Each pixel has a color defined by a set of three digital values defining strength of the primary color components, red, green and blue (RGB) respectively. In one embodiment, 10 each frame is divided into an array of 300 by 300 pixels, with the color and luminance of each pixel being defined by a seven bit word for the red component, a seven bit word for the blue component, and a seven bit word for the green component. These words are generated by ADC 24. 15 The RGB video signal may also be processed by means of hue-saturation-intensity (HSI) color processing, where appropriate, as described in "Chips for Real-Time Comparisons," Electronic Engineering Times, issue 525, February 13, 1989, page 122.

20 If each frame includes 90,000 pixels (300 x 300), and each pixel is defined by 21 bits (7 bits per primary color), the digital representation of a single video frame utilizes a sizable block of digital information (i.e., 1.89 megabits/frame) which must be processed very 25 rapidly. (Approximately 30 frames/second are received from AVRU 11.) Fortunately the analog to digital conversion of these signals may be accomplished at the desired speed using commercially available analog to digital converter integrated circuits. The analog to 30 digital converter 24 (ADC) is a high-speed, high-accuracy, A to D "flash" converter available as a single IC (integrated circuit). Several different types of such A/D converters are available from Burr-Brown, one of which is the ADC 600. Part number TIC024, manufactured by 35 Tektronix, Inc. is also appropriate. Other types of

devices appropriate for this function are described in an article by K. Rogers entitled "8-bit A/D Flash Hits 500 Msamples", Electronic Engineering Times, Dec. 12, 1988, page 90, incorporated herein by reference.

5       Compression of the digital data defining a video frame and the reverse process (decompression) are accomplished by compressor/decompressor 26. Various algorithms may be employed in the compression process which enable the representation of a series of numbers by  
10      a reduced number of digits. As an example, compression algorithms like CCITT Group IV may be used.

      In one optional embodiment, to further reduce the amount of memory required to store a program, the compression algorithm can simply record data corresponding  
15      to only those pixels which change color from one frame to the next. This results in considerable memory space savings, since not all pixels change color each frame. Basing calculation upon 10% of the pixels changing from one frame to the next, it is estimated that memory  
20      requirements using this technique are cut by about 90%. It is also estimated that on the average, the CCITT Group IV algorithm can cut memory requirements by another 95%. Thus, if no data compression technique is used, it would take approximately 51.03 gigabytes to store a 2 hour  
25      video program, but by using the above compression techniques, it is estimated that memory 13 will require only 250 megabytes.

      Controller 27 handles timing and aids in the communication between the different elements of VCU 12, and between VCU 12, AVRU 11 and memory 13.

      In one embodiment, the audio portion of the program is periodically sampled and digitized by analog to digital conversion. In one embodiment, this is done at a sample rate of 88,000/second, one byte per sample, to yield  
35      compact disc quality sound. The sampling rate could be

dropped to reduce memory requirements. Also, the audio data can be compressed with conventional algorithms.

The process of converting either from analog to digital or from digital to analog requires memory for 5 intermediate storage. Random Access Memory (RAM) 29 serves in this capacity. For this purpose either a DRAM (Dynamic RAM) or a SRAM (static RAM) may be employed. An example of a DRAM is the TI (Texas Instruments) TMX4C1024; an example of a SRAM is the INMOS IMS-1203. RAM 29 should 10 have sufficient capacity to store at least two full uncompressed frames (e.g., about 472 KB).

The CPU (Central Processing Unit) 28 is a micro-processor which controls the digitization process of VCU 12. CPU 28 works with controller 27 to control and 15 communicate with the other elements of the VCU. There are numerous commercially available microprocessors that are appropriate for this application. The Intel 80286, Intel 80386, Motorola 68020, and Motorola 68030 are examples. A more complete description of the microprocessors can be 20 found in the October 27, 1988 issue of Electronic Design News (EDN), pages 231 and 242, incorporated herein by reference, or in the applicable data sheets.

Controller 27, CPU 28 and RAM 29 serve in the same manner during the reverse processes, i.e., decompression 25 and digital to analog conversion. Decompression is first accomplished in compressor/decompressor 26. The decompressed digital signal is then converted to an analog signal by digital to analog converter (DAC) 24 (assuming its destination requires an analog form). In the course 30 of converting the decompressed signals from the VCU 12 for use by the AVRU 11 the signals are synchronized by the time base generator (TBG) or corrector 48. TBG generator 48 inserts synchronization pulses into the signal provided by VCU 12 to identify individual raster scan lines and 35 frames so that the resulting signal can be used by a

conventional television set or VCR. TBG 48 can be bypassed by shunt switch 48' for the purpose of transmitting either compressed or decompressed signals from VCU 12 directly to the AVRU 11 in an uncorrected time based mode.

DAC 25 provides the inverse of the function performed by A/D converter 24. DAC 25 is a high-speed, high accuracy digital to analog converter. An example of such a converter is the Burr-Brown DAC60 digital to analog converter.

Different types of memory technologies are adaptable for use in memory 13. As mentioned earlier, DRAM and SRAM semiconductor memories are commonly used for applications of this type and are readily available.

One type of random access memory is CMOS (Complimentary Metal Oxide Semiconductor). The CMOS memory has the advantage of a relatively low power requirement and is readily adaptable for use with battery backup for semi-permanent data storage. Other types of memory include the above mentioned optical disc memories, bubble memories and magnetic discs. Another appropriate data storage media may be "Digital Paper" available from ICI Image data of Wilmington, Delaware.

Emerging memory technologies may also prove advantageous with capabilities for mass data storage in even smaller physical dimensions.

Digital Control Unit (DCU) 14 comprises a CPU (Central Processor Unit) 31, a ROM (Read Only Memory) 32 and a controller 32. DCU 14 is responsible for all of the digital editing processes. Through the use of DCU 14, video segments may be edited and rearranged. Thus, one may use DCU 14 to rearrange the scenes in a program, alter the program sound track, etc.

In addition, a program may be edited, one frame at a time, by changing the contrast, brightness, sharpness,

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colors, etc. (Alteration of the contrast, brightness, sharpness and colors can be automated as well.) In one embodiment, images can be rotated, scaled (i.e., made larger or smaller), etc. In addition, pixel by pixel 5 editing can be accomplished by DCU 14, e.g., in a manner similar to a PC paint program. Similar editing features can be incorporated for the audio portion of each program. In one embodiment, a display such as a flat panel video display (not shown) is built into the 10 VCR-ET. A user interface control panel of DCU 14 allows a user to select a desired frame number from a menu on the display. The VCR-ET then displays a strip of frames (including several frames before and after the selected frame). The user can delete frames in a strip, select a 15 point where other frames are to be inserted into the program, or edit different frames (i.e., alter contrast, brightness, sharpness, colors, etc.). In one embodiment, a user input device such as a light pen or mouse can be used to select individual frames in a strip for editing. 20 Instead of incorporating a flat display into VCR-ET 10, in another embodiment, a television coupled to output lead 42 of RF modulator 19 can be used during editing. 25 CPU 31 is a microprocessor of the type described in connection with the CPU 28 of VCU 12. Controller 33 is an integrated circuit which handles the timing and interfacing between DCU 14 and memory 13. ROM 32 holds the necessary step-by-step editing programs which are installed at the factory. A currently available example 30 of a suitable ROM for this application is the Texas Instruments part TMS47256. CPU 31 and controller 33 together control the editing process as they execute the programs stored in ROM 32. 35 The VCU 12, memory 13 and DCU 14 communicate with each other via a high speed data bus 34. The high speed data bus is required in order to meet bandwidth

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requirements. Examples of suitable data bus devices are Motorola's VME bus, Intel's Multibus and the Optobuss (U.S. Patent 4,732,446).

A video line or camera input line 15 is provided to 5 enable VCR-ET 10 to receive an input signal from a source such as a television camera, a conventional VCR, a television tuner, or another VCR-ET, etc. The signals received at input line 15 are typically carried by a coaxial cable and are in the form of a standard television 10 composite signal. As used throughout this specification, the words "standard television composite signal" or its acronym STCS shall be read to include any one of the following: NTSC, PAL, SECAM, HDTV, or any American or European broadcast signal standards. (NTSC, PAL and SECAM 15 are discussed in "Reference Data for Radio Engineers", published by Howard W. Sams & Co. in 1983, incorporated herein by reference.) An NTSC composite signal is defined as the analog signal that carries the chrominance (color), luminance (brightness), synchronization (timing) and audio 20 signals that make up the video signals received and displayed by television and video cassette recorders. These four components are combined into one signal by modulating the components in different ways. (Amplitude modulation and phase modulation are examples.) The 25 standard video line signal is such a composite signal and may be received at input line 15 from one of the above-mentioned sources.

TV RF tuner input port 16 also supplies a composite signal as described in regard to video input line 15. The 30 difference is that this signal is received from an antenna or cable TV coaxial cable. To receive such a signal, tuner 16 is capable of being set or tuned to receive the desired carrier frequency or television channel.

Selector switch 35 is provided to select either video 35 input line 15 or TV RF tuner 16 as an input signal source

to AVRU 11.

Auxiliary digital input port 17 is employed to receive any acceptable digital signal such as a computer-generated video signal or as may be supplied by another 5 VCR-ET. This signal, for example, may be an RGB video signal such as that delivered to computer monitors, or it may be a digitized audio signal. (As mentioned above, an RGB signal is a signal which communicates the strength of the red, green and blue color components for the pixels 10 that make up each video frame.) Switch 36 selects whether the digital video/audio input signal is chosen from auxiliary digital input port 17. Switch 36 supplies the selected signal to high speed data bus 34 which carries the signals in digital form.

15 Fiber optic port 18 incorporates a fiber optic transceiver. Port 18 is capable of transforming fiber optic (light) signals to electrical signals or transforming electrical signals to fiber optic signals. Port 18 thus provides a capability for two-way 20 communication between high speed data bus 34 and a fiber optic signal line. The incorporation of fiber optic port 18 in the VCR-ET provides a capability for receiving audio/video signals from or delivering audio/video signals to the fiber optic line such as a fiber optic telephone 25 line. The fiber optic line carries digital signals in the form of light waves over great distances with a high degree of accuracy and reliability and at a high speed (e.g., about 200 megabytes/second). The VCR-ET can receive/transmit a video program at an accelerated rate 30 via fiber optic port 18 from/to a variety of sources. For example a video program may be communicated at an accelerated rate from the first VCR-ET to a second VCR-ET in less time than it would take to view the program. Thus, it is not necessary to access the optical fiber for 35 long periods of time in order to transmit a long video

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program.

(Using fiber optic port 18, a movie can be downloaded in less than 10% of the time required to view the movie, and typically less than 1% of the time required to view 5 the movie.) Thus, it is not necessary to access the optical fiber for long periods of time in order to transmit a long video program. Switch 37 is provided to select connection to the fiber optic input/output port 18. An OFF or open position is provided. The selected 10 signal is delivered to or supplied from high speed data bus 34.

Switch 37 is provided to select connection to the fiber optic input/output port 18. An OFF or open position is provided. The selected signal is delivered to or 15 supplied from high speed data bus 34.

Analog output signals from AVRU 11 are delivered to the common terminal 38 of a selector switch 39. When set to position A, switch 39 delivers the output signal of AVRU 11 directly to a video output line 41 as a standard 20 STCS composite signal; when set to position B switch 39 delivers the output of AVRU 11 to the input of RF modulator 19. Modulator 19 converts the video signal to an RF-modulated composite signal for delivery to such devices as televisions and conventional VCR's. These 25 types of devices play back the video program on a particular frequency channel (such as channel 4) on the television. Delivery to the television or VCR is via RF output line 42.

Digital output signals from VCR-ET 10 may be 30 dispatched from high speed data bus 34 via line 43 to input leads of RGB converter 21 and audio/video transmitter/receiver 22.

RGB converter 21 converts the STCS signal into an RGB signal as required by computer monitors and similar 35 display devices. The converted signal is received by a

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display device connected to RGB converter output line 44. (In another embodiment, digital signals may be dispatched from high speed data bus 34 via line 43 to the input lead of RGB converter 21.)

- 5        VCR-ET 10 includes audio/video transmitter/receiver 22 which is typically a built-in modem. Advantageously, the modem may be used to communicate an audio/video program over conventional phone lines in a manner similar to that described above with respect to optical fibers.
- 10      The modem allows transfer of the audio/video signal in a digital format over the standard telephone line. Modems are commonly available for computers and are currently available in the form of a single integrated circuit. As an example, Sierra Semiconductor offers a 2400 baud single
- 15      chip modem as part number SC111006. Representative manufacturers of these single modem IC's can be found in the April 14, 1988 issue of Engineering Design News (EDN), pages 124-125. Some of these single IC modems have the added capability of generating the tones for dialing a
- 20      phone number. The destination phone number may be entered by means of an optional keyboard/keypad 45 incorporated in the video recorder 10 of the invention. Output port 46 of transmitter/receiver 22 connects directly to the telephone line.
- 25      Also associated with Modem 22 is an auxiliary keyboard 45' (Fig. 1A) of buttons for commanding the modem to perform tasks such as starting a transmission over phone lines (45a), terminating a transmission (45b), automatic telephone answering to receive transmissions
- 30      (45c), using an optional speaker (not shown) to monitor phone lines (45d), using an optional microphone (not shown) to speak over the phone lines (45e) and for controlling the baud rate (45f).

The application and utilization of the VCR-ET may 35 include a number of forms or operating modes. In its

first and simplest operating mode, AVRU 11 may be operated in the manner of a conventional VCR with signals from an antenna being received by tuner 16 and recorded directly on media 23 in analog form. At the same time the received 5 program may be viewed on the television screen with the television connected at video output terminal 42. An optional signal source for this type of operation is the video line or camera input line 15 selectable by switch 35.

10 In a second operating mode a program stored in media 23 of AVRU 11 may be played back and viewed on the connected television set.

When it is desired to copy a program from one recording media to another, the recording media holding 15 the desired program is installed in the AVRU. The recording media is then played back with optional viewing on a connected television set or other TV monitor and/or listening through speakers (as appropriate). As the recording media is played back, the analog signals from 20 the recording media (video and/or audio) are dispatched to VCU 12 via connection 47. The analog signals are converted to digital signals by ADC 24, compressed by compressor/decompressor 26 and the compressed digital signals are stored in memory 13. The foregoing operations 25 are accomplished under the control of controller 27 and CPU 28. RAM 29 is used for interim data storage during this process. Once the complete video/audio program has been stored in memory 13, the recording media from which the stored program has just been read is replaced by blank 30 recording media upon which the stored program is to be copied. CPU 28 in cooperation with controller 27 and RAM 29 then executes the decompression and digital to analog conversion of the program stored in memory 13, decompression taking place in compressor/decompressor 26, 35 and digital to analog conversion being accomplished by DAC

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25. The resulting analog program is stored on the blank recording media which constitutes media 23 of AVRU 11.

In an alternate mode of operation, the decompression circuitry of VCU 12 can be bypassed. Thus, a user has the  
5 option of downloading the stored program from memory 13 onto recording media 23 in compressed digital format. The user can then reload the program from media 23 into memory 13 at a future time for viewing, editing or recording back onto recording media 23 in analog form. This capability  
10 allows the user to quickly clear memory 13 for other interim uses and also provides the user with a hard copy of the program in digital format. The hard copy in compressed digital format has a number of uses, e.g. it could be archived for later viewing, transmitted by an  
15 appropriate independent transmitter, etc.

During the foregoing procedures, DCU 14 may be utilized for editing operations. As the program is being read from the first or original recording media, it is simultaneously viewed on the TV screen, or listened to by  
20 means of an audio monitor, converted to digital signals, compressed and stored in memory 13. Once the digital audio/video program is stored in memory 13, editing is accomplished by the user through control of DCU 14, by means of a control panel (not shown) coupled to DCU 14.

25 If desired, additional audio/video signals may be simultaneously entered into memory 13 and added to those received from VCU 12. The additional signals may be introduced from auxiliary digital input port 17 or from fiber optic input/output port 18 and may comprise video  
30 captions to be superimposed upon the stored video images, or they may be audio commentaries to be added to silent video presentations. In addition, as mentioned above, the order in which various segments appear in the video programs may be altered. Certain undesired segments, such  
35 as TV commercials, may be removed. This editing operation

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is accomplished under the control of DCU 14.

In still another operating mode, a program stored in media 23 of AVRU 11 or being received by AVRU 11 from input line 15 (as from a video camera) may be digitized 5 and compressed by VCU 12 and routed via bus 34, to memory 13. The data from memory 13 is then routed to line 43, transmitter/ receiver 22 and to a telephone line (or to fiber optic port 18 and to an optical fiber). At the other end of the telephone line (or optical fiber) the 10 signals received are processed by another VCR-ET.

Once received in the second VCR-ET's memory 13, the digitized program can then either be viewed directly from memory or transferred to storage medium 23, either in its entirety or in random segments, based on user preference.

15 In the case of video camera input at input 15 the transmitted signals may comprise a live transmission. Alternatively the transmitted program may be derived from a program stored in media 23 of AVRU 11. In this case the stored analog program is again decoded, digitized, 20 compressed and transmitted via bus 34 to memory 13. The data in memory 13 is then communicated via line 43 and transmitter/receiver 22 to telephone lines or other output means (e.g. fiber optic port 18).

It follows, of course, that digitized video and audio 25 signals from the remote VCR-ET at the other end of the telephone line may be received at line 46, entered into memory 13 via transmitter/receiver 22, converted to analog signals by VCU 12, and recorded on media 23 and then viewed, if desired, on a television set connected at 30 output 42. A hard copy of the program may also be made for later viewing.

As mentioned earlier, when any of the foregoing operations entail the processing of unmodulated video signals, such signals must first be processed by RF 35 modulator 19 before they can be accepted by devices such

as a conventional VCR or television set; when the monitoring means is a computer monitor or a similar display device the signals are processed by RGB converter 21.

5 All of the foregoing operations are performed with enhanced quality and efficiency by virtue of the digital, rather than analog, storage and transmission modes and the compressed data storage mechanism, with additional advantages of improved cost and reliability afforded in  
10 the case of tape to tape (or other media to media) program transfers by virtue of the requirement for only a single tape deck or other storage device.

In an alternative embodiment, either in place of fiber optic port 18 or in addition to fiber optic port 18,  
15 a microwave transceiver 18' is provided for transmitting and/or receiving a video program via microwave. In conventional microwave technology, satellite systems and microwave transmitters transmit data using a low power/high frequency signal. In an embodiment of the  
20 invention designed to receive microwaves, transceiver 18' includes an amplifier for amplifying the microwave signal and a demodulator for obtaining the video program signal from the microwave signal. Receiving, amplifying and demodulating the microwave signal can be accomplished with  
25 conventional microwave transceiver equipment. The video program signal is typically in compressed digital form, and may be stored, viewed or edited as in the above-described embodiments. Video program data from memory 13 can also be transmitted by the microwave transceiver,  
30 thereby providing the capability for microwave transmission of stored video programs in compressed digital format. Thus, the invention can be used to receive and transmit programs via microwaves at an accelerated rate similar to and about as fast as, the  
35 transmission and reception of programs over optical

fibers. This feature allows transmission and reception of programs in a few minutes or seconds using currently available technology. Both point-to-point microwave transceivers and satellite transceivers may be used.

5 In one embodiment, VCR-ET 10 receives video programs which are downloaded from a remotely located video library 100 (Fig. 5) at an accelerated rate via microwave transceiver 18'. After downloading, the program may be viewed, stored in memory, edited and/or a hard copy of the 10 program may be made on magnetic tape, optical disk, etc. Thus, a VCR-ET owner who subscribes to video library 100 may request (via telephone or other means) that a particular film be downloaded via microwave to the subscriber's VCR-ET, e.g., VCR-ET 10. Other subscribers 15 may simultaneously request that other movies be downloaded into their VCR-ET's 10a to 10d (Fig. 5) via microwave. Library 100 transmits a video signal corresponding to the various movies requested by various users in series.

In one embodiment, each VCR-ET includes a memory 20 device 90 (shown in phantom in Fig. 2) for storing a subscriber's identification code unique to that VCR-ET. As the video library broadcasts signals via microwaves, prior to commencement of each signal corresponding to a movie (or other video program), the library broadcasts a 25 preamble signal including the subscriber's code corresponding to the VCR-ET for whom the movie signal is intended. Each VCR-ET includes a monitoring circuit 92 for monitoring the microwave signal received by microwave transceiver 18'. When transceiver 18' receives a preamble 30 signal corresponding to the subscriber code stored in memory device 90, VCR-ET 10 stores the video signals received thereafter in memory 13 for subsequent viewing. In this way the video library may broadcast, in series, compressed video signals at an accelerated rate to be 35 downloaded into VCR-ET's owned by various subscribers. If

- 20 -

a plurality of subscribers request the same film, the library broadcasts a signal preamble containing the plurality of subscribers' codes corresponding to the VCR-ET's of each subscribing VCR-ET owner who requested

5 that film, so that each requesting subscriber simultaneously receives the requested film. In one embodiment, the VCR library prioritizes the order in which films are broadcast based upon the number of subscribers requesting each film.

10 In another embodiment, a plurality of VCR-ET's are coupled via their optical fiber port 18 and a common optical fiber to the video library. In yet another embodiment, instead of receiving signals from the video library using microwaves or optical signals, such video

15 signals are received via radio waves of a frequency such as are used to communicate conventional television signals. In one such embodiment, these radio wave signals are modulated using a technique described in U.S. patent 4,613,974, issued to Vokac et al. on September 23, 1986,

20 and incorporated herein by reference. In the Vokac modulation technique, the sine waves that make up the radio signals are modified to include what Vokac refers to as "audel levels" i.e. a relatively flat signal portion 110 between the peaks 112 and troughs 114 of the sine

25 waves (see Figure 6). In one embodiment, TV RF tuner 16 is coupled to Vokac demodulation circuitry 16 (Fig. 2A) which is capable of demodulating signals encoded using Vokac's technique, and downloading these signals via lead 94 to memory 13.

30 The use of Vokac's technique in this embodiment is important because Vokac's technique allows for a single carrier signal to be modulated by two other signals. A first of these two other signals is used to modulate the carrier to encode data by introducing into the carrier

35 Vokac's "audel levels" 110. In addition, the carrier may

be phase, amplitude or frequency modulated using the second other signal. In this way, an electro-magnetic carrier signal in the radio or television band may be encoded with two information signals. The first of these 5 signals may be a conventional commercial television program, impressed upon the carrier signal via phase modulation (or frequency or amplitude modulation) and destined for televisions owned by people who do not subscribe to the video library. The second signal may be 10 audel-level encoded with data corresponding to a compressed digital video signal destined for subscribers, whose VCR-ET decodes the audel levels (using the circuitry disclosed in the Vokac patent) and loaded into memory 13 for subsequent viewing.

15 As described in the Vokac patent, between each peak 112 of Vokac's signal and an audel level is a first portion 116 of a first transition region, and between each audel level and a signal trough is a second portion 118 of the transition region. When demodulating signals 20 modulated with Vokac's technique, the demodulation circuitry may be responsive to the slope of the first and second portions 116, 118 of the transition regions, or it may be responsive to the magnitude of the audel level 110, directly.

25 In the embodiment in which compressed video signals are transmitted by an electro-magnetic carrier signal in the radio or television band, monitoring circuit 92 may be coupled to TV RF tuner 16 instead of microwave transceiver 18.

30 Fig. 3 illustrates an alternative embodiment invention in which AVRU 11 is not integral with VCU 12, memory 13 or editor 14. In this embodiment, AVRU 11 is a conventional, commercially available VCR which receives a modulated video input signal on an input cable 50. In 35 this embodiment AVRU 11 includes a RF tuner 51 for

demodulating the input signal so it can be stored in media 23. AVRU 11 also includes a RF modulator 52 for modulating the signal received from media 23 and providing the RF modulated output signal on an output cable 53, 5 which can be coupled to a television set. (TV RF tuner 51 and RF modulator 52 are provided in typical commercially available VCR's.) A switch 54 is provided to couple input cable 50 to output cable 53 when media 23 is not serving as a video signal source. The VCR-ET of this embodiment 10 includes a TV RF tuner 55 which receives and demodulates the signal on cable 53, and provides the resultant analog audio/video signal on a lead 56, which is digitized and compressed as described above. In this alternative embodiment, the digitized compressed signal may be 15 processed as described above, e.g. stored in memory 13 (via high speed bus 34), edited, transmitted by the fiber optic port 18 to another VCR-ET, etc. When it is desired to view a program stored in memory 13, data from memory 13 is decompressed and converted to an analog signal by 20 VCU 12, and the resulting signal is provided on an output lead 57 to a RF modulator 58, which modulates the video signal so that it can be received and stored by AVRU 11 or viewed on a television coupled to cable 53. (As mentioned above, in the Fig. 3 embodiment, AVRU 11 is a conventional 25 VCR.)

One advantage of the embodiment of Fig. 3 is that many people already own VCR's. Rather than buying apparatus which duplicates much of the hardware already present in their VCR, the embodiment of Fig. 3 would 30 provide to owners of conventional VCR's capabilities which are otherwise currently unavailable.

In one embodiment, analog auxiliary audio and video input terminals 62, 64 are provided so that analog signals may be provided by alternate sources to VCU 12.

35 The embodiments described include means for

receiving, storing and transmitting both audio and video signals. However, the invention encompasses apparatus which can store and transmit video signals only and apparatus which can store and transmit audio signals 5 only. An embodiment designed to store and compress audio signals is illustrated in Fig. 4. Referring to Fig. 4, an audio signal source 70 (a tape recorder, microphone, record player, etc.) is coupled to a digitizer and compressor circuit 72, which converts the analog signal to 10 a digital signal and compresses the digital signal in a manner similar to VCU 12 described above. (Audio signal source 70 may also be a CD player which provides digital audio signals, in which case circuit 72 merely compresses but does not digitize the CD player output signal.) The 15 digital compressed signal can then be stored in a memory 74. Of importance, data from memory 74 can be transmitted by a fiber optic transceiver 76, or by a microwave transceiver 78 at an accelerated rate. This is important not only in a home entertainment application, but in other 20 applications as well. For example, a user can dictate an audio presentation and send it to a remote location (e.g. an office) at an accelerated rate without having to monopolize the transmission medium (e.g. the fiber optic cable) for an extended length of time.

25 The business uses of the embodiment illustrated in Fig. 4 makes home offices feasible for many workers now confined to more traditional offices and also opens new possibilities to business people who are traveling.

In the embodiment of Fig. 4, data can also be loaded 30 from memory 74, via a modem 79 over a conventional phone line 80. Data can also be received from phone line 80, fiber optic transceiver 76 or microwave transceiver 78, loaded into memory 74, and converted to an analog signal by circuit 72, to be listened to via an audio monitor 82, 35 or to be stored on an audio tape cassette 84 or other

storage media.

An editor 86 is optionally provided so that the data in memory 74 may be edited, e.g., by rearranging the order of portions of the audio program, increasing or decreasing 5 the volume of portions (or different frequency components) of the audio program, or enhancing the audio program through filtering techniques (e.g. to remove static and noise).

It will be apparent to those skilled in the art that 10 various changes and modifications may be made to the above-described embodiments without departing from the spirit of the invention or from the scope of the appended claims. For example, the VCR-ET can be constructed so as to be portable. Thus, it could be carried to a location 15 where it is desired to record a program with a video camera, and used to edit the program after it is recorded. Also, in one embodiment, video library 100 can download video programs via optical fiber or other means. Also, in other embodiments, an audio library is 20 provided to download digital compressed audio signals. Other modifications will be apparent to those skilled in the art in light of the present specification.

CLAIMS

What is claimed is:

1. Apparatus comprising:

5 first means for receiving an input video signal,  
which provides video information at an accelerated  
rate;  
second means for storing said video signal; and  
means for receiving from said second means said  
10 stored video signal and generating an output video  
signal which provides video information at a rate at  
which it can be viewed.

2. Apparatus of Claim 1 wherein said input video  
signal is a compressed digital video signal and said  
output video signal is an analog video signal.

15 3. Apparatus of Claim 1 wherein said input video  
signal is received from a microwave transceiver, RF tuner,  
optical fiber, telephone line or coaxial cable.

4. Apparatus of Claim 1 wherein said first means is  
also capable of receiving an input video signal at a rate  
20 at which it can be viewed.

5. Apparatus comprising:

means for receiving a video input signal that  
provides video information at a first rate; and  
means for providing a video output signal  
25 including said video information at a second rate  
greater than said first rate.

6. Apparatus of Claim 5 wherein said input video  
signal is an analog video signal and said output video

signal is a digital compressed video signal.

7. Apparatus of Claim 5 wherein said output video signal is transmitted by a microwave transceiver, an optical fiber, radio transmitter, telephone line or 5 coaxial cable.

8. Apparatus comprising:

means for receiving an input video signal;  
memory means for storing data;  
means for generating a compressed digital video 10 signal in response to said input video signal and storing said compressed digital video signal in said memory means; and  
reconstruction means for receiving said compressed digital video signal from said memory 15 means and reconstructing therefrom an output video signal suitable for viewing.

9. Apparatus of Claim 8 further comprising means for editing said digital compressed video signal stored in said memory means.

20 10. Apparatus of Claim 9 wherein said means for editing permits a user to alter the sequences of segments of said compressed digital video signal.

11. Apparatus of Claim 9 further comprising means for displaying images of said digital compressed video 25 signal being edited.

12. A video recording device comprising:

first memory means for storing analog video signals;

second memory means for storing digital video

signals; and

conversion means for receiving said analog video signals from said first memory means, converting said analog video signals to digital video signals, and storing said digital video signals in said second memory means, said conversion means also being capable of converting said digital video signals stored in said second memory means back into analog video signals for storage in said first memory means.

10 13. Video recording device of Claim 12 wherein said first memory means is a magnetic, optical or semiconductor memory, and said digital video signals are compressed digital video signals.

14. Video recording device of Claim 12 further comprising means coupled to said first memory means and conversion means for receiving an analog input video signal, whereby said analog input video signal may be stored in said first memory means or converted to a digital video signal by said conversion means.

20 15. Apparatus comprising:

means for receiving an analog audio signal;  
means for digitizing said analog audio signal, thereby generating digital data corresponding to said audio signal and for compressing said digital data;  
25 memory means for storing said compressed digital data; and  
transceiver means for transmitting said compressed digital data.

16. Apparatus of Claim 15 wherein said transceiver 30 means also receives compressed digital data and stores said received compressed digital data in said memory

means, said apparatus also including means for decompressing and converting the data stored in said memory means into an analog audio signal.

17. Apparatus of Claim 15 further comprising means 5 for editing said compressed digital data.

18. Apparatus comprising:

means for receiving a first signal from a communication channel corresponding to audio information during a first time period;

10 means for receiving said first signal and reconstructing sound waves therefrom so that said sound waves may be listened to during a second time period substantially longer than said first time period so that it is unnecessary to access said 15 communication channel for a time equal in duration to said second time period.

19. Apparatus comprising:

first means for receiving and converting an analog audio signal to a digital audio signal;

20 second means for storing said digital audio signal, wherein said first means is also capable of receiving said digital audio signal from said second means and reconverting said digital audio signal back to an analog audio signal for listening;

25 third means for storing data; and

fourth means for transferring said digital audio signal from said second means to said third means, thereby making said second means available for receiving and storing additional digital audio 30 signals.

20. Apparatus of Claim 19 wherein said first means

also compresses data, so that said digital audio signal is a compressed digital audio signal, and wherein said third means is a memory device capable of receiving said digital audio signal from said second means, said third means also 5 being capable of receiving and storing said reconverted analog audio signal from said first means.

21. Apparatus of Claim 20 wherein said third means is remote from said first and second means and said fourth means comprises a microwave transceiver.

10 22. Apparatus of Claim 20 wherein said third means is remote from said first and second means and said fourth means comprises an optical fiber.

15 23. Apparatus of Claim 20 wherein said third means is remote from said first and second means and said fourth means comprises a telephone line.

24. Apparatus of Claim 19 wherein said third means is also capable of storing an analog audio signal for subsequent listening.

25. Apparatus comprising:  
20 receiving means for receiving and storing an audio signal in a first memory means during a first time period;  
communication means for communicating said stored audio signal during a second time period  
25 substantially less than said first time period.

26. Apparatus of Claim 25 wherein said receiving means converts said received audio signal from an analog to digital format prior to storage, and said communication means transmits said stored audio signal to a location

- 30 -

remote from said apparatus.

27. Apparatus comprising:

receiving means for receiving and storing an audio signal in a first memory means during a first time period; and

means for providing said stored audio signal to a speaker so that said signal can be listened to during a second time period substantially greater than said first time period.

10 28. Apparatus of Claim 27 wherein said receiving means receives said audio signal in digital format and converts said received audio signal from said digital format to an analog format, said receiving means receiving said audio signal from a location remote from said 15 apparatus.

29. Apparatus comprising:

first means for receiving an electromagnetic wave signal from a video library, wherein at least part of said signal corresponds to a video program received at an accelerated rate; and

second means for storing said part of said signal corresponding to said video program so that said video program may later be viewed.

30. Apparatus of Claim 29 wherein said part of said 25 signal corresponding to said video program comprises compressed digital data corresponding to said video program, and said signal is a radio band signal or a television band signal.

31. Apparatus of Claim 30 further comprising a video 30 monitor and means for receiving and decompressing said

- 31 -

compressed digital data and reconstructing therefrom a video signal, and providing to said video monitor said reconstructed video signal.

32. Apparatus of Claim 31 wherein said first means receives said video program in less than 10% of the length of time required to view the video program.

33. Apparatus of Claim 30 wherein said second means stores said part of said signal corresponding to said video program in compressed digital form, said apparatus further comprising:

an RF tuner for receiving a television signal;  
a video recorder for storing said television signal for subsequent viewing;  
third means for decompressing said compressed digital data from said second means to reconstruct therefrom a video signal, said third means being coupled to said video recorder so that said reconstructed video signal may also be stored on a video storage medium, said second means also being coupled to said video recorder so that said compressed digital data can be downloaded onto said storage medium.

34. Apparatus of Claim 33 wherein said video recorder is in a common housing with said first, second and third means.

35. Apparatus of Claim 33 wherein said video recorder is not in a common housing with said first, second, and third means.

36. Apparatus comprising:  
30 first means for receiving an electromagnetic

wave signal from an audio library, wherein at least part of said signal corresponds to an audio program received at an accelerated rate; and

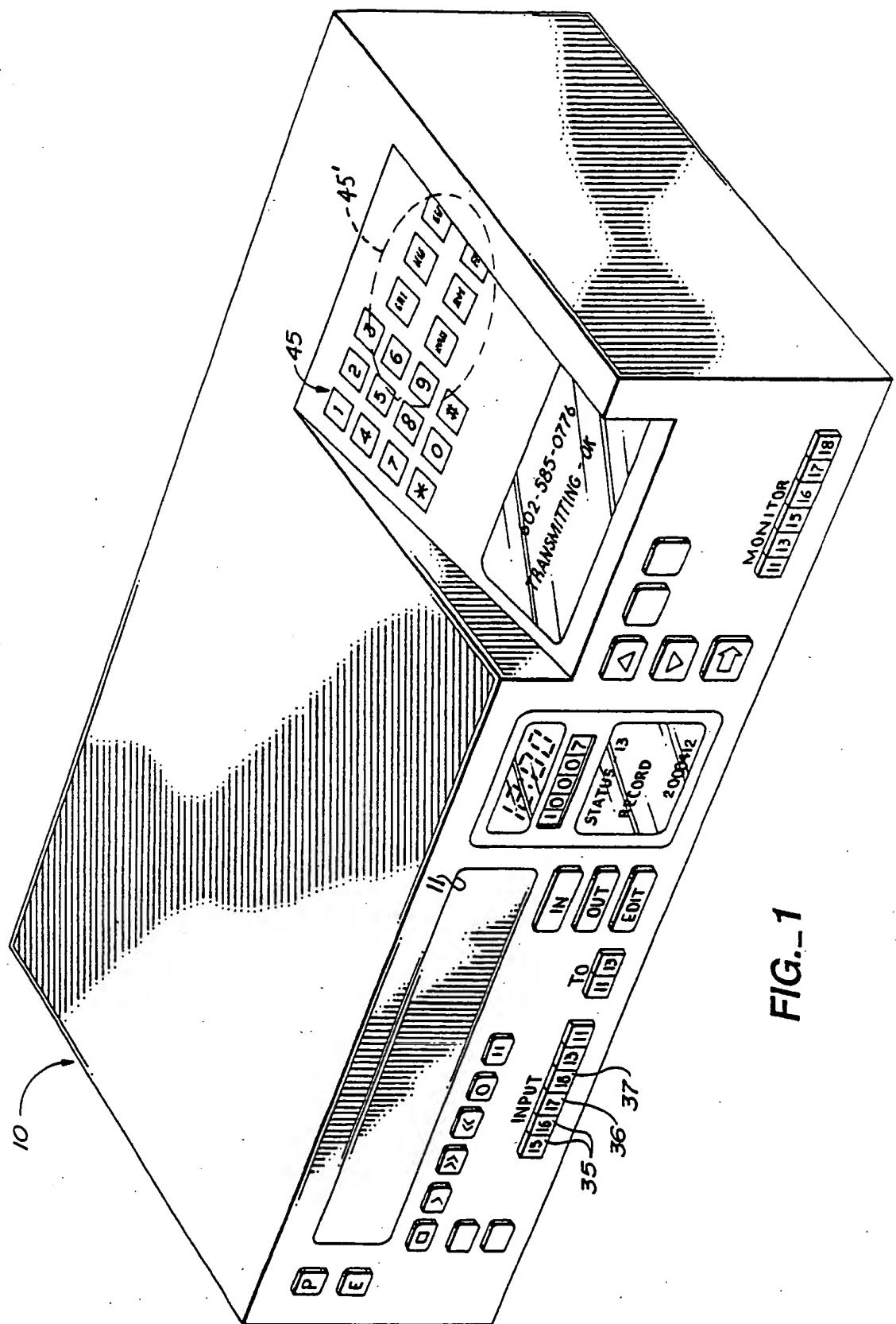
5 second means for storing said part of said signal corresponding to said audio program so that said audio program may later be listened to.

37. Apparatus of Claim 36 wherein said part of said signal corresponding to said audio program comprises compressed digital data corresponding to said audio 10 program, and said signal is a radio band frequency signal or a television band frequency signal.

38. Apparatus of Claim 37 further comprising a speaker and means for receiving and decompressing said compressed digital data and reconstructing therefrom an 15 audio signal, and providing to said speaker said reconstructed audio signal.

39. Apparatus of Claim 38 wherein said first means receives said audio program in less than 10% of the length of time required to listen to the audio program.

20 40. Apparatus of Claim 37 further comprising means for editing said compressed digital data stored in said second means.

**SUBSTITUTE SHEET**

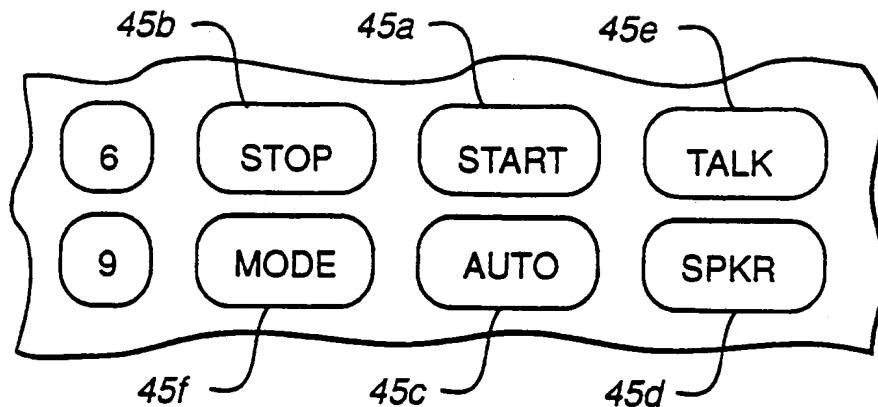


FIG. 1A

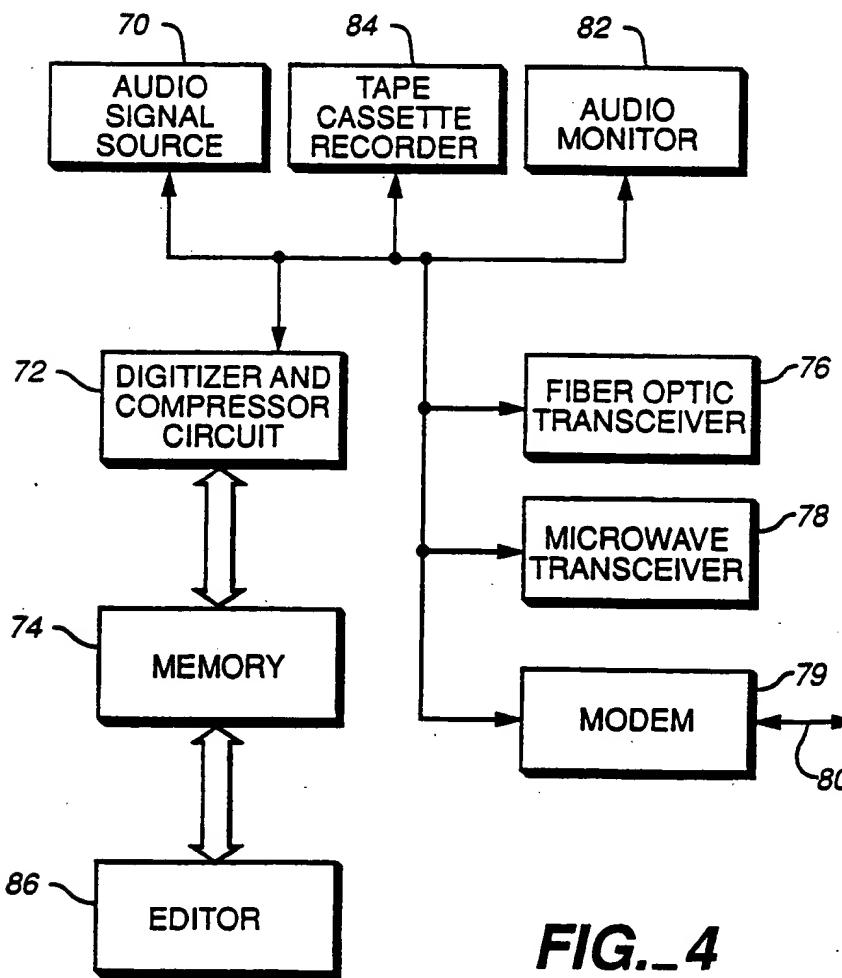
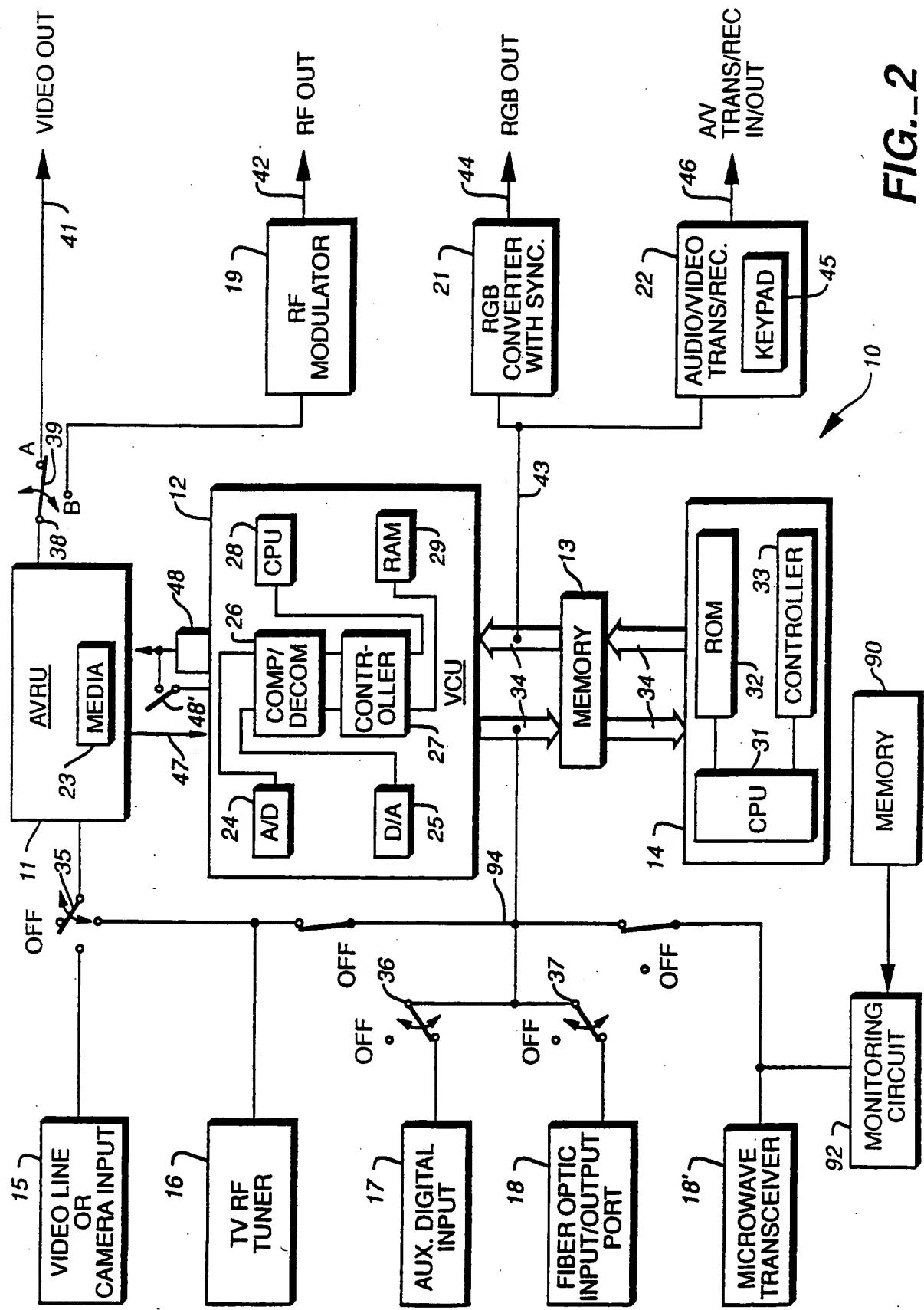
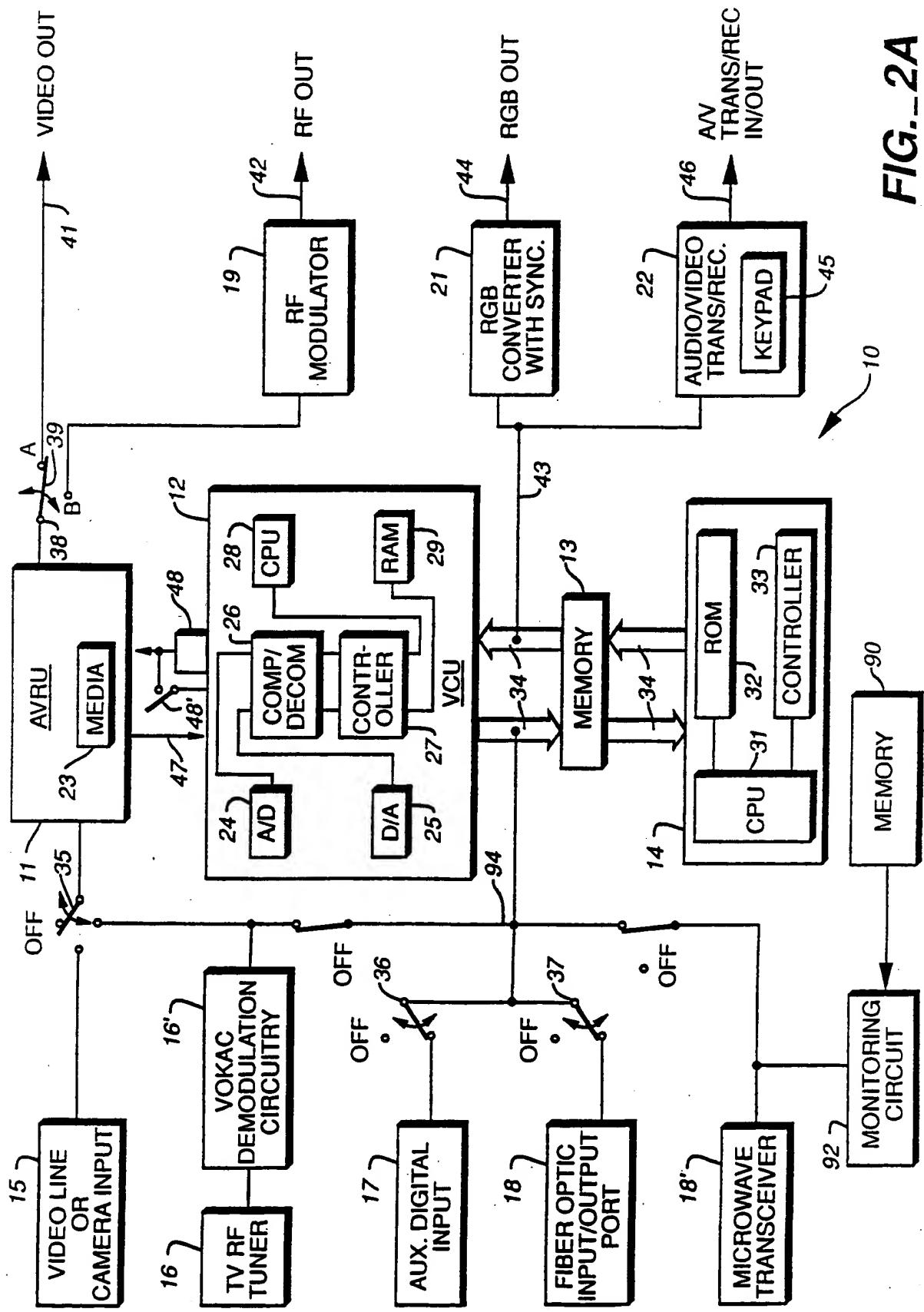
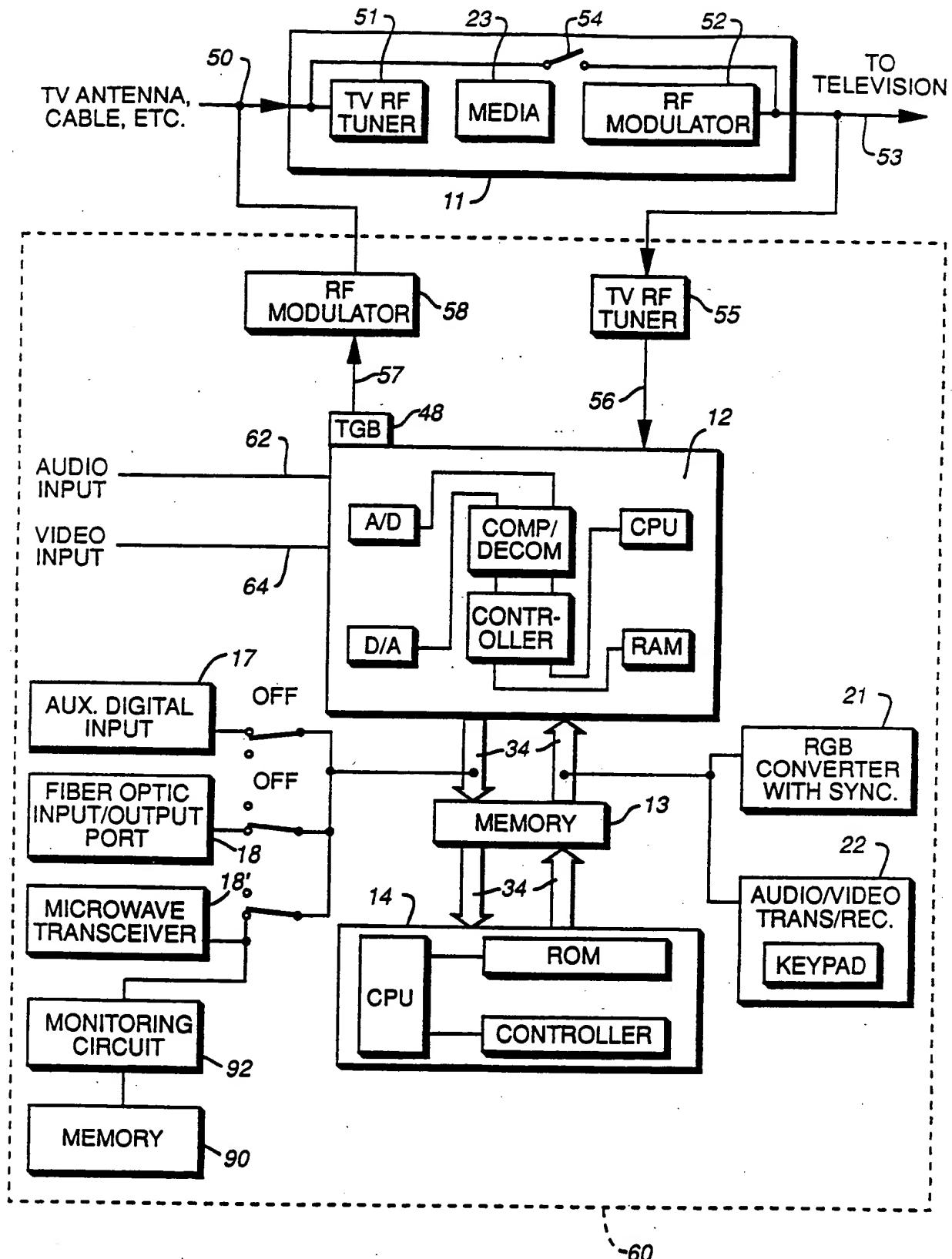


FIG. 4

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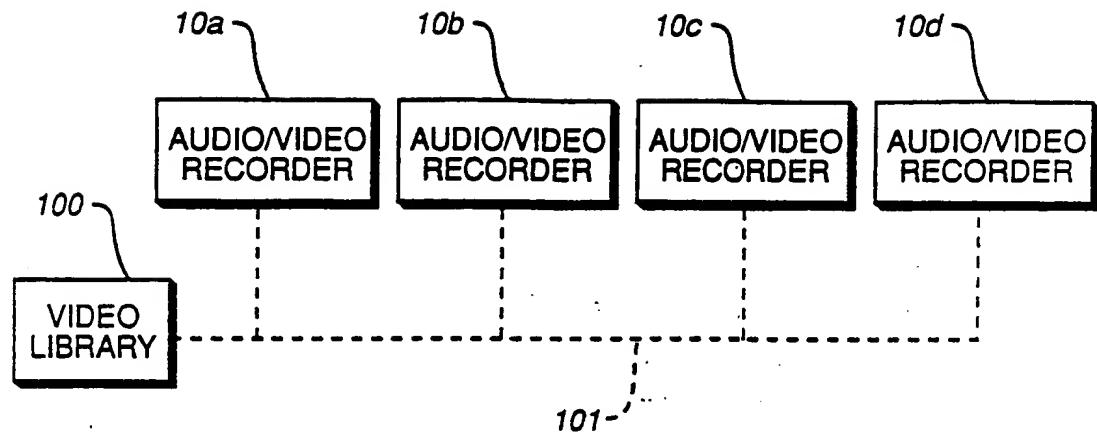
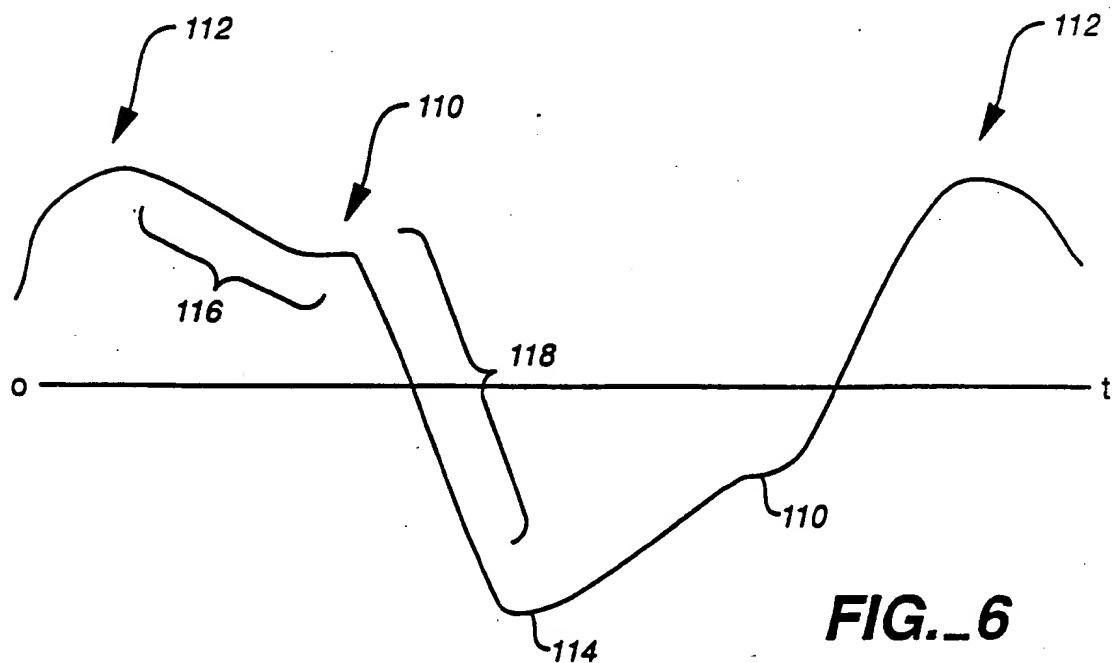






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FIG.\_3

**FIG.\_5****FIG.\_6****SUBSTITUTE SHEET**

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US89/05829

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4) H04N 5/76

U.S. CL. 358/335

## II. FIELDS SEARCHED

Minimum Documentation Searched<sup>7</sup>

| Classification System | Classification Symbols                                       |
|-----------------------|--------------------------------------------------------------|
| U.S.                  | 358/133,134,135,136,137,138,335<br>360/9.1,32,14.1,14.2,14.3 |

Documentation Searched other than Minimum Documentation  
to the Extent that such Documents are Included in the Fields Searched<sup>8</sup>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup>

| Category <sup>10</sup> | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup> | Relevant to Claim No. <sup>13</sup> |
|------------------------|----------------------------------------------------------------------------------------------------------------|-------------------------------------|
| X                      | US, A, 4,698,664 (NICHOLS ET AL) 06 October 1987<br>See col. 3, lines 5-60.                                    | 1-14                                |
| P,X                    | US, A, 4,851,931 (PARKER ET AL) 25 July 1989<br>See col. 2, lines 59-68 and col. 15 lines 33-68.               | 15-40                               |

## \* Special categories of cited documents: 10

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"Z" document member of the same patent family

## IV. CERTIFICATION

Date of the Actual Completion of the International Search

07 MAY 1990

Date of Mailing of this International Search Report

24 MAY 1990

International Searching Authority

ISA/US

Signature of Authorized Officer

ROBERT L. RICHARDSON  
*Robert L. Richardson*

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